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THE BIOLOGY AND DISTRIBUTION OF CALIFORNIA HEMILEUCINAE (SATURNIIDAE)

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ABSTRACT. The distribution, biology, and larval host plants for the 14 species and subspecies of California Hemileucinae are discussed in detail. In addition, the immature stages of *Hemileuca neumogeni* and *Coloradia velda* are described for the first time. The relationships among the *Hemileuca* are examined with respect to six species groups, based on adult and larval characters, host plant relationships and pheromone interactions. The *tricolor, eglanterina,* and *nevadensis* groups are more distinctive than the *electra, burnsi,* or *diana* groups, but all are closely related. Species groups are used to exemplify evolutionary trends within this large but cohesive genus.

The saturniid fauna of the western United States is dominated by moths of the tribe Hemileucinae. Three genera in this tribe commonly occur north of Mexico: *Hemileuca*, *Coloradia*, and *Automeris*. Although no *Automeris* are native to California about 50% of the *Hemileuca* and *Coloradia* species in the United States occur in the state. The absence of *Automeris* and other species from California is due to the state's effective isolation from southern Arizona and mainland Mexico by harsh mountains, deserts, the Gulf of California, and climatic differences. The *Hemileuca* of northern Arizona, Nevada, and Utah are very similar to that of California, while those of Oregon, Washington, and Idaho represent subsets of the northern California fauna.

The majority of the saturniid species in the United States have had little or no impact on man, but some Hemileucinae have been of economic importance. In California, the larvae and pupae of *Coloradia pandora* have been utilized by indians as a food source (Aldrich, 1911, 1921). Other species, especially in the genera *Automeris*, *Hemileuca* and *Saturnia* have urticating spines which can inflict a painful sting; the resulting welt can persist for days. Larvae of the range caterpillar, *Hemileuca oliviae*, have often reached pest status by damaging range grasses utilized by cattle in Oklahoma and Texas (Ainslie, 1910; Watts & Everett, 1976; Huddleston et al., 1976; Coleman, 1982). The larvae of *Coloradia pandora* undergo periodic outbreaks at which time the larvae have damaged or defoliated large stands of pines (Chamberlin, 1922; Patterson, 1929; Wygant, 1941). In California, *pandora* reaches the status of a pest about once every 30 years. Other species have been nuisances locally on crops or ornamentals but have never consistently been abundant or caused economic losses.

In the last 30 years there have been two major publications dealing with the Saturniidae of the United States. In his work on the Saturniidae of the Western Hemisphere Michener (1952) dealt with the mor-

phology, phylogeny, and classification of the group. Ferguson (1971, 1972) authored a two part series on the Saturniidae of the United States and Canada and illustrated in color most of the species, presented line drawings of the male genitalia, and summarized their biology. Ferguson's work condensed most of the available information on the saturniid fauna north of Mexico. It became clear that relatively little was known about the distribution, biology, and immature stages of many western species, particularly in the tribe Hemileucinae. The purpose of this paper is to discuss the Hemileucinae of California and to present new information regarding their biology, distribution, and immature stages.

Unless specifically indicated, diagnostic information on adults or immature stages is not intended as redescriptions but merely to help the reader recognize the uniqueness of each taxon. Distribution records are based on a review of specimens in the collections of: The University of California at Berkeley, Davis, and Riverside; California State Universities at San Diego, San Jose, Fresno, and Humboldt; Natural History Museums of San Diego, Los Angeles, and Santa Barbara as well as the collection at the California Academy of Science, San Francisco; the private collections of Steve McElfresh, Ken Hansen, John Johnson, Mike Collins, Sterling Mattoon and the author. In addition the author has traveled and collected extensively in this area and has reared all of the species occurring in the western states. Information on flight period is based on observation and capture records for wild specimens in collections; emergence dates from specimens which were obviously reared were excluded, as was distribution data on mislabeled specimens. Distribution maps are provided to show trends, and in most cases the maps should be considered as a conservative estimate (Fig. 5).

Genus *Hemileuca* Walker

Hemileuca are medium to large moths with wingspans ranging from 3 to 9 cm. Moths in this genus include nocturnal and diurnal species and occur from desert to alpine habitat. Although some species are widely distributed with ranges from Mexico to Canada, the majority are restricted to Arizona, California, Nevada, Texas, and Mexico. Eight species of *Hemileuca* occur in California representing four of the six species groups. Michener (1952) recognized four subgenera and treated *Pseudohazis* as a junior synonym of *Hemileuca* based on adult morphology. Ferguson (1971) and Tuskes (1978) presented additional information which supports the merger of *Pseudohazis* and *Hemileuca*. *Hemileuca chinatiensis* (Tinkham) and *H. griffini* Tuskes (Fig. 2m) have genitalia, wing shapes, wingspans, sexual dimorphism and larval characters which place them at a transitional point between *Hemileuca*

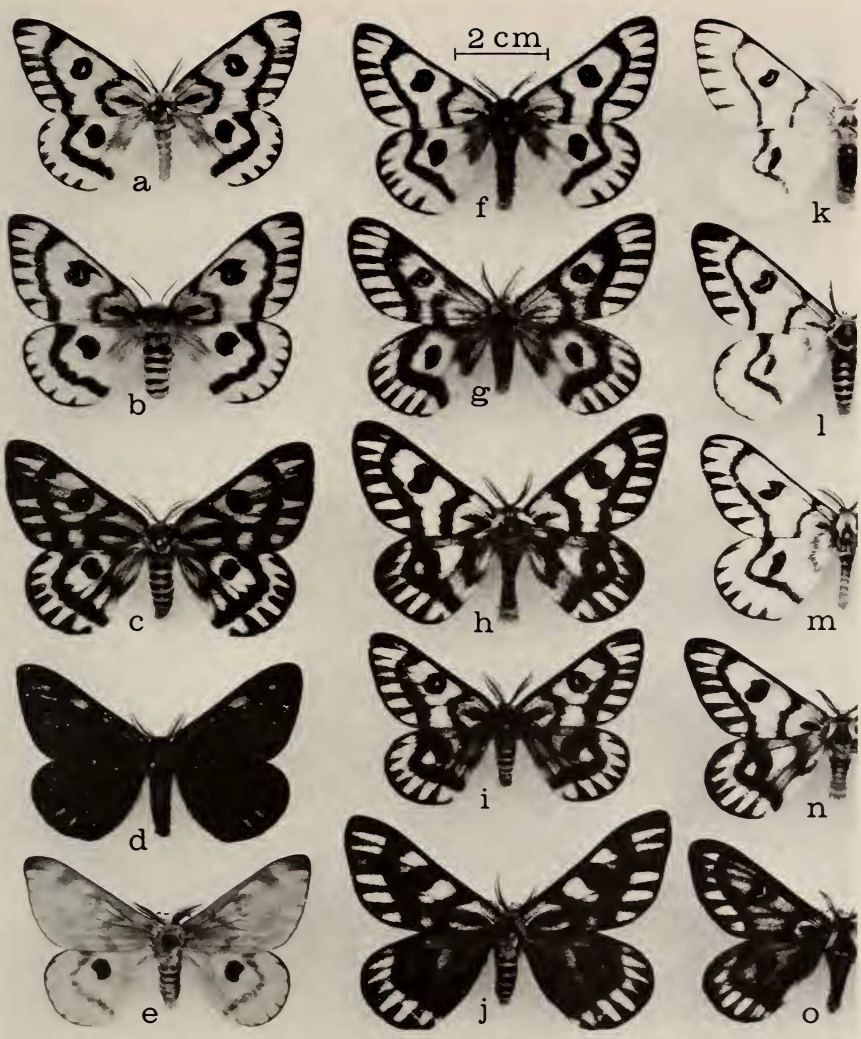

FIG. 1. *Hemileuca* of California. **a & b.** *H. eglanterina eglanterina*, ♂ & ♀; **c & d,** *H. eglanterina shastaensis*; **e,** *H. eglanterina eglanterina* form denudata; **f & g,** *H. nuttalli uniformis*; **h,** *H. hera hera*; **i,** *H. eglanterina annulata*; **j,** *H. eglanterina annulata*, Elko Co., Nevada; **k,** *H. hera marcata*, Klam. Co., Oregon; **l & o,** *H. hera hera*, Modoc Co., Calif.

and *Pseudohazis* (Table 1). Within the genus there are six distinct species groups which are based on male genitalia, wing pattern, external adult morphology, behavior, larval morphology, and larval host plant preferences at the family level (Table 1).

FIG. 2. *Hemileuca* and *Coloradia* of California. **a**, *H. electra electra* ♀; **b**, *H. electra electra* ♂; **c**, *H. juno* ♀; **d**, *H. juno* ♂; **e**, *H. neumoegeni* ♀; **f**, *H. burnsi* ♀; **g**, *H. electra clio* ♀; **h**, *H. electra clio* ♂; **i**, *H. nevadensis* ♀; **j**, *H. nevadensis* ♂; **k**, *H. neumoegeni* ♂; **l**, *H. burnsi* ♂; **m**, *H. griffini* ♂, Az.; **n**, *H. diana* ♂, Az.; **o**, *H. tricolor* ♂, Az.; **p**, *C. velda* ♂; **q**, *C. velda* ♀; **r**, *C. pandora lindseyi* ♂. *Hemileuca griffini*, *H. diana*, and *H. tricolor* do not occur in California but were included as representatives of species groups or transitional taxa discussed in the text; the latter three species are from Arizona.

Pheromone attraction tests show positive interaction between many species groups (Table 2). For example, female *electra* will attract and mate with males of *burnsi*, *diana*, and *eglanterina* as well as all *eglanterina* subspecies. Females of *nevadensis*, which are superficially sim-

TABLE 1. Relationships among the *Hemileuca* of the United States.

Male genitalia grouping*	Primary hostplant	Time of oviposition	♀ much larger than ♂	Larval paniculum concolor	Pupation in soil/ leaf litter
electra group					
electra	Polygonaceae	day/night	yes	no	yes
juno	Leguminosae	day/night	yes	no	yes
burnsi group					
burnsi	Compositae/Rosaceae	night	yes	no	yes
neumoegeni	Rosaceae/Anarcadiaceae	night	yes	no	yes
diana group					
diana	Fagaceae	day	yes	no	yes
grotei	Fagaceae	day	yes	no	yes
maia group					
nevadensis	Salicaceae	day	yes	no	yes
maia	Fagaceae/Salicaceae	day	yes	no	yes
lucina	Rosaceae	day	yes	no	yes
eglanterina group					
eglanterina	Rosaceae/Salicaceae/ Celastraceae	day	no	yes	yes
nuttalli	Caprifoliaceae/Rosaceae	day	no	yes	yes
hera	Compositae	day	no	yes	yes
griffini	Rosaceae	day	some	some	yes
chinatiensis	Leguminosae	day	yes	no	yes
tricolor group					
tricolor	Leguminosae	night	yes	no	no
oliviae	Gramineae	night	yes	no	no
hualapai	Gramineae	night	yes	no	no

* Wing pattern grouping is the same.

ilar to those of the *diana* group, will not attract either *diana* or *grotei* males. Based on Tables 1 and 2, the *tricolor*, *eglanterina* and *nevadensis* groups are the most distinctive, and any further revision which might reestablish *Pseudohazis* to generic status would have to recognize the *tricolor* and perhaps the *nevadensis* groups as unique. Such splitting would accomplish little, and hide the morphological, biological, and behavioral relationships which they share. Much needs to be learned about the Mexican species before the status of the entire group can be dealt with properly. Presently the *Hemileuca* appear to be a rather cohesive group containing distinctive but closely related assemblages of species.

Biology of *Hemileuca*

Adult moths emerge from their pupation site in the soil or leaf litter during the morning and climb shrubs or grasses prior to wing expan-

TABLE 2. Intrageneric attraction and mating between 11 western species of *Hemileuca*. Unless otherwise indicated tests were made with caged females and wild males in the field.

Calling female	Male tested	Results At./Ma.	Calling female	Male tested	Results At./Ma.
burnsi	*electra*	no*	*electra*	*eglanterina*	yes
chinatiensis	*diana*	no*		*annulata*	
chinatiensis	*eglanterina*	no	*electra*	*eglanterina*	yes
chinatiensis	*nevadensis*	no*		*shastaensis*	
chinatiensis	*eglanterina*	no	*electra*	*hera*	no
	shastaensis		*electra*	*nuttalli*	no/yes*
diana	*nevadensis*	no*	*electra*	*burnsi*	yes
diana	*grotei*	yes	*electra*	*diana*	yes
diana	*juno*	no?	*electra*	*electra clio*	yes
eglanterina	*nuttalli*	yes	*hera*	*eglanterina*	no
eglanterina	*hera*	no	*hera*	*nuttalli*	no
eglanterina	*eglanterina*	yes	*juno*	*diana*	yes
	shastaensis		*nevadensis*	*grotei*	no
eglanterina	*eglanterina*	yes	*nevadensis*	*lucina*	yes*
	annulata		*nuttalli*	*hera*	no
eglanterina	*nevadensis*	no*	*nuttalli*	*eglanterina*	no/yes*
electra	*eglanterina*	yes			

At./Ma. = attraction and mating.
* = male reared and caged with female.

sion. Newly emerged females release pheromones that may attract dozens of males to their location within a few minutes. Usually females begin to emit pheromones after their wings have expanded. Mating requires 20 minutes to an hour, during which time the pair remain almost motionless. In captivity, male *eglanterina* have mated consecutively with three females, each of which produced fertile ova.

Shortly after mating the female deposits ova in a ring (Fig. 3k) around the branch she is perched on (if it is the host plant) or may fly for a short period of time prior to oviposition. After the first egg ring is completed she frequently flies for five to 15 minutes and then deposits a second egg ring which usually contains fewer eggs than the first. Depending on the species, eight to over 300 ova may be deposited in a ring. Oviposition generally occurs on stems 2 to 8 mm in diameter. Although females of our western species usually mate only once, in certain populations of *H. maia* the female may mate again after depositing the first egg ring.

The majority of eggs in any given ring usually hatch within two days of each other. Early instar larvae are black, but as they mature, species specific color patterns develop. Since many of the western species hatch between December and April, the dark coloration and their gregarious nature may play an important role in their thermoregulation (Fig. 3l). Larval phenotypes of *eglanterina, nuttalli, griffini,* and

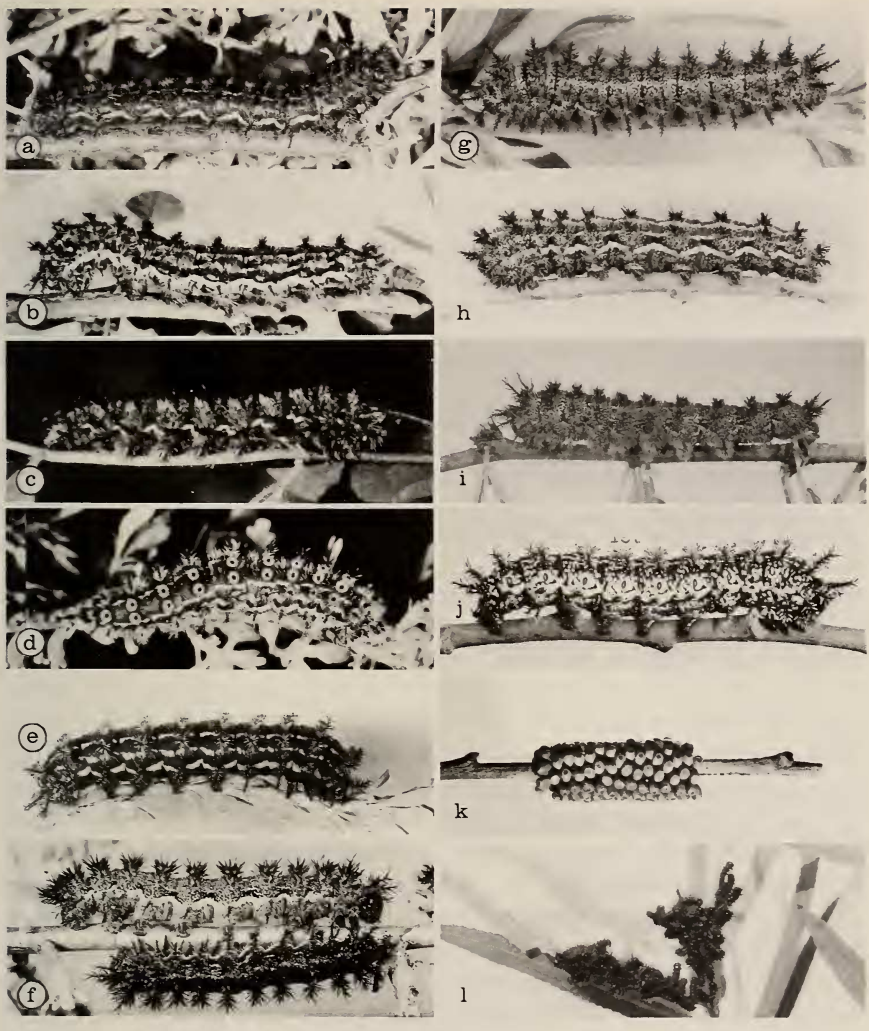

FIG. 3. Last instar *Hemileuca* larvae of California. **a,** *H. eglanterina shastaensis*; **b,** *H. eglanterina annulata*; **c.** *H. nuttalli uniformis*; **d,** *H. nuttalli nuttalli*; **e,** *H. hera hera*; **f,** *H. neumoegeni*; **g,** *H. burnsi*; **h,** *H. electra electra*; **i,** *H. juno*; **j,** *H. nevadensis*; **k,** *H. nevadensis* egg ring; **l,** First instar larvae of *H. nevadensis* feeding on willow.

nevadensis are generally consistent within a population, but striking differences are often found between different populations (Figs. 3a, b, c, d). The larvae of *electra*, *burnsi*, *juno*, *neumoegeni*, and *hera* usually exhibit little variability. A key to the last instar saturniid larvae of the West Coast has been published, and includes some host plant and habitat data (Tuskes, 1976). All *Hemileuca* larvae are covered with

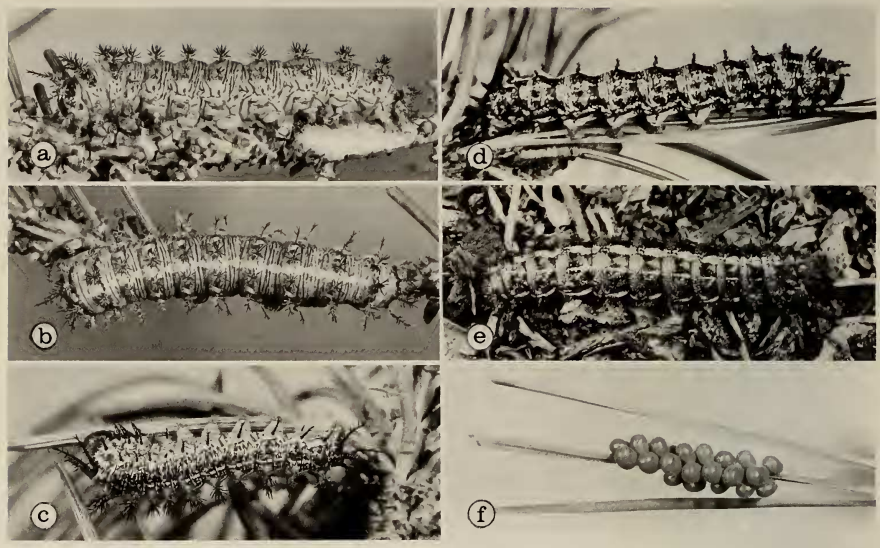

FIG. 4. *Coloradia* larvae of California. **a,** *C. velda,* mature; **b,** *C. velda,* mature; **c,** *C. velda* (4th instar); **d,** *C. pandora lindseyi,* mature blackish phenotype (Mono Co., Ca.); **e,** *C. pandora lindseyi,* mature brown phenotype (San Diego Co., Ca.); **f,** *C. pandora lindseyi* egg cluster on pine needle.

short secondary setae and various types of urticating scoli on the dorsal and lateral surfaces. When disturbed gregarious larvae may respond by moving the body segments anterior to the prolegs back and forth at a frequency of about 1 cycle per second. At times almost every larva in the cluster may oscillate in synchrony. The urticating scoli of *Hemileuca, Automeris,* and *Saturnia* larvae are capable of inflicting a severe sting. The irritation may last for half an hour, and the affected area may discolor; welts lasting from one to 14 days may develop. The intensity of the pain inflicted by the larval scoli seems to vary from one species to the next.

In the 4th or 5th instar the larvae lose their gregarious tendencies and feed individually. At this time they disperse over a wider area of the host plant or to surrounding plants. When a larva is mature it leaves the host plant and wanders on the ground in search of a suitable location to pupate. All of the California species pupate either in the leaf litter, under objects such as rocks, burrow into the ground, or utilize deep cracks in the soil. The pupal cell consists of debris or soil held together with a loose matrix of silk which forms a cup over the pupa with little or no silk below. The cell is fragile and merely picking it up often results in its destruction. An exception are the members of

the *tricolor* group, many of which spin a loose but complete silken cocoon that is attached to vegetation.

The length of time spent in the pupal stage for any given species varies from population to population. In areas with a long growing season, overwintering eggs hatch in the spring, develop, and emerge as adults later that same summer. Where the growing season is short (e.g. coastal fog belt, or subalpine) adults and larvae from different generations may overlap. Pupae from spring larvae may emerge, mate, and deposit eggs, or overwinter and hatch the following summer. Thus, in some populations, eggs and pupae rather than just eggs function as the overwintering stage. I refer to this as an asynchronous two year life cycle with an adult flight each year. All of the California species have the ability to spend two or more years in the pupal stage.

Hemileuca eglanterina eglanterina (Boisduval)

Hemileuca eglanterina (Figs. 1a, b, e) is the only western saturniid with a dorsal forewing that is yellow, black, pink, and occasionally beige. The antemedial and postmedial lines and margin are black. In some populations the females have more pink on the forewing than males. Dorsally, the hindwings are black and yellow. The ventral wing surface is always black, yellow, beige, and frequently pink. The abdomen of both sexes is alternately banded black and yellow, but in some individuals one color may dominate the pattern. There is a great deal of geographic variation within this species. Specimens from southern California are often smaller and have less pink on the forewings than northern populations. The form "denudata" is widespread in populations from central California to Washington, although the frequency of its occurrence varies greatly from one population to the next. All specimens expressing the "denudata" trait have been males in which the black markings are either greatly reduced or absent, therefore the wings are predominantly pink or yellow. Another distinctive phenotype is one in which the yellow has been replaced by brown.

Typical *eglanterina* blends into the Great Basin subspecies, *annulata*, along the passes on the east slopes of the Sierra Nevada. A second subspecies, *shastaensis* is characterized by melanic adults and occurs in extreme northern California and southern Oregon. Male and female *eglanterina* are of similar size. California specimens of the nominate form have wingspans that range from 63 to 72 mm.

The flight season extends from late June to early October, but the majority of the records are from mid-July through the last week of August. Both males and females are active day flyers.

Hemileuca eglanterina occurs in a wide variety of habitats. In dry areas such as the Central Valley, *eglanterina* occurs in the riparian

habitat where the larval host plants are various species of *Salix*. In the chaparral community, as well as in pine, oak, or redwood forests, the larvae feed extensively on *Ceanothus* and *Cercocarpus*. Host plants which are used less frequently or by specific populations include: *Prunus, Pyrocantha, Purshia, Rubus, Quercus*, and *Symphoricarpos*. On occasion this species has been common in residential areas and orchards.

Although the phenotype of the last instar larva is fairly uniform within a given population, there is a great deal of variability between populations. Last instar larvae have 1 to 3 complete cream colored lateral lines, but in some populations they are absent. The ventral surface, intersegmental area, and prolegs vary in coloration from black to red. The ground color is black, dark gray, or dark brown; the dorsal scoli are yellow and black.

Egg rings on *Salix* are easily located during the winter. Each ring may consist of 75 to over 250 ova. In the Central Valley the eggs begin to hatch in mid to late March, and last instar larvae can be collected from mid-May to mid-June. At the lower elevations *eglanterina* has a one year life cycle, but at higher elevations or along the coast it has an asynchronous two year life cycle with an adult flight each year.

Hemileuca eglanterina shastaensis (Grote)

Hemileuca eglanterina shastaensis (Figs. 1c, d) is distinguished from typical *eglanterina* by its melanic tendencies and distribution. Although some males are totally black on the dorsal surface, the majority have a moderate amount of pink on the forewing and yellow on the hindwing. Even the darkest males express 3 of the 4 basic *eglanterina* colors on the ventral wing surface: black, yellow, and pink. Males exhibit a full range of phenotypes from black to only slightly melanic. Females have a definite tendency to be lighter in coloration, and some appear similar to the nominate form except for having a more extensive rose-pink coloration on the dorsal forewing. Specimens in California collections have wingspans which range from 65 to 78 mm.

The flight season extends from mid-June to mid-August, but the majority of the records are from mid-July. Both males and females are active day flyers and are usually closely associated with the chaparral plant community.

Larval masses have been collected by the author numerous times on *Purshia tridentata* (Pursh) in California and Oregon and reared to maturity in captivity on *Cercocarpus*. Wild cherry is another possible host according to Ferguson (1971). All of these plants are in the family Rosaceae, a group commonly used by typical *eglanterina*. Early instar larvae of *shastaensis* may be collected in May or June, and mature

larvae looking for pupation sites are frequently observed crossing roads in mid-July to August. Mature larvae measure 50 to 70 mm in length and are reddish brown with bold cream colored lateral lines; the intersegmental area is deep red. This subspecies has a two year asynchronous life cycle on Mt. Shasta as adults and larvae can be collected at the same time. Larvae reared in the Central Valley exhibited a one year life cycle (Fig. 3a).

A cross between a female *shastaensis* and a typical male *eglanterina* produced offspring that appeared almost identical to the male parent, except that they had a deep rose color on the forewing which is characteristic of many *shastaensis*. Because of staggered emergence the F_1 could not be backcrossed or selfed. Additional matings between *shastaensis* and nominate *eglanterina* are needed to determine their relationship to each other.

Hemileuca eglanterina annulata Ferguson

Hemileuca eglanterina annulata (Figs. 1h, i) has the typical *eglanterina* pattern but may be distinguished from the nominate form by the reduction or absence of pink on the forewing and a tendency for the black markings to be more extensive, often with a smudged appearance. In California, specimens of *annulata* may be confused with *H. nuttalli uniformis*, but the two species may be separated by examining the hindwing postmedial black line between vein M_3 and the inner margin of the wing; this line is straight or convex in *annulata* and concave in *nuttalli*. In addition, the ventral surface of California *annulata* is usually black, yellow, and beige, while California *nuttalli* are black and yellow. Some *annulata* females are only black and yellow; if so, the forewing postmedial coloration will separate them from female *nuttalli*. In Nevada and Arizona, *annulata* is larger than *nuttalli*. California specimens have wingspans that range from 60 to 73 mm. Specimens from Nevada and Arizona reach 85 mm and are frequently darker.

The flight season of *annulata* extends from late June to early September, with the majority of the records from mid-July to mid-August. Both males and females are active day flyers from 1000 to 1630 h, with a peak near 1200 h.

In California, *annulata* is restricted to the Great Basin habitat on the dry eastern slopes of the Sierra Nevada, where it integrates with the nominate form. Specimens from this area are the same size as the nominate form but usually have smudged black maculation and lack bold pink markings on the forewings. Some individuals have a slightly diffuse pinkish yellow cast over the forewing, while other populations have little or no pink. Although California populations are variable and

are both smaller and lighter in coloration than Nevada and Arizona populations, they are best described as *annulata* with some genetic input from typical *eglanterina*. The adults are usually seen flying near the larval host plants which include: *Prunus emarginata* (Dougl.), *Ceanothus velutinus* (Dougl.), *Purshia tridentata* (Pursh), and *Symphoricarpos vaccinoides* (Rydb.). Mature larvae from California are similar to those from the Central Valley except the cream colored lateral stripes are more prominent, and the ventral surface is usually light red (Fig. 3b).

Hemileuca nuttalli uniformis (Cockerell)

The forewing of male *nuttalli uniformis* (Figs. 1f, g) is cream to beige dorsally, with a black basal patch, antemedial, and postmedial line, discal spot, and margin. In addition (as in *eglanterina* and *hera*), black wedge-shaped marks extend from the margin towards the postmedial line. The forewing of the female is very similar to the male, but the area between the margin and the postmedial line is yellow in the female rather than beige as in the male. The ventral surface of the fore- and hindwings are yellow and black. The thoracic tufts are yellow, and the abdomen has alternate bands of black and yellow. This species is frequently sympatric with *annulata*, and the two are often confused. For diagnostic differences see *H. eglanterina annulata*. Male and female *nuttalli* are of similar size; wingspans range from 60 to 68 mm. Specimens from Arizona and Nevada are frequently larger, 66 to 78 mm, and their pattern is more diffuse.

In California, *nuttalli* flies from mid-July to perhaps mid-September, with the peak flight period in August. Both males and females are active day flyers.

This subspecies inhabits the eastern slopes of the Sierra Nevada from Inyo Co. north to Alpine Co. at elevations generally ranging from 2150 to 3400 m. Although probably widespread in this area, limited access to the proper habitat has resulted in relatively few collecting records. Specimens from Nevada and northern Arizona are slightly larger, and the black markings are frequently more diffused than Sierran material. Ferguson (1971) suggested that the *uniformis* phenotype may be the result of its cool environment. On two occasions the author reared Sierran *uniformis* in the hot Central Valley, and the resulting adults expressed the *uniformis* phenotype.

Although frequently sympatric with *H. eglanterina annulata* and *H. hera* in the mountains, *uniformis* infrequently occurs on the high plateau east of the Sierra, an area dominated by sagebrush and saline soils. Collins and Tuskes (1979) found that male *uniformis* are attracted to and will mate with female *eglanterina*. Such interspecific matings

are minimized in the wild by a partially allochronic flight period. Female *uniformis* have a tendency to mate later in the day than female *eglanterina*. Male *uniformis* fly from 1030 to 1800 h, with 75% of their flight activity after 1330 h. Male *eglanterina annulata* at the same location flew from 1030 to 1630 h, with about 75% of their flight activity prior to 1330 h. Female *uniformis* did not attract male *annulata*.

Overwintering egg rings hatch in late April or May and pupation occurs in July. The larval host plants in California are *Purshia tridentata* (Pursh) and *Symphoricarpos vaccinoides* (Rydb.). In the Sierra Nevada *uniformis* has an asynchronous two year life cycle with an adult flight each year. When reared at lower elevations *uniformis* has a one year cycle. The larvae of *uniformis* from Monitor Pass, Mono Co. have 1 prominent and 2 poorly developed cream colored lateral lines. The ground color is black and there are numerous grayish short secondary setae; the dorsal rosette setae are yellow and black. The head is black and mature larvae measure 53 to 63 mm in length (Fig. 3c).

Hemileuca nuttalli nuttalli (Stecker)

Adult *nuttalli nuttalli* differ from *nuttalli uniformis* in subtle ways. The nominate form is said to be larger and the black markings well defined rather than diffused as in *uniformis* (Ferguson, 1971). In addition, the forewing of female *nuttalli* has a uniform yellow cast with black maculation, while that of *uniformis* is beige with a yellow cast only between the postmedial line and wing margin; the maculation is also black but slightly more diffused.

Flight data were not available since all of the California records have been from reared specimens. In Oregon this form flies during July and August. Both males and females are active day flyers.

Typical *nuttalli* is common in southern Oregon and has been collected in extreme northern California. In Siskiyou Co. the larvae have been found feeding on *Purshia tridentata* and *Symphoricarpos*. Pupation occurs during July and early August; adults emerged the following August. The larvae of *nuttalli* are extemely variable. MacFarland (1974) described mature nominate *nuttalli* from eastern Oregon as black, with no maculation, and with black scoli. Larvae from Siskiyou Co., CA have prominent yellow dorsal scoli, and 3 distinct cream colored lateral lines; the ground color is black, and there are numerous short secondary setae on the segmental areas (Fig. 3d).

Hemileuca hera hera (Harris)

The fore- and hindwing of *H. hera* (Fig. 1h) are white with a black basal patch, antemedial line, postmedial line, discal spot, and marginal

areas. The costal area is black, and the veins between the marginal and postmedial line are covered with triangular-shaped patches of black scales. The head and anterior portion of the thorax are yellow, dorsal thoracic area black, thoracic tufts white. The abdomen is alternately banded with yellow, black, and occasionally white. Specimens from the Sierra Nevada are frequently darker than those from the adjoining Great Basin. Both male and female *hera* are of similar size; the wingspan of California specimens ranges from 59 to 73 mm.

The flight season extends from late June to mid-September with the majority of the records from July to early August. Both males and females are active day flyers.

The larvae of *hera* feed almost exclusively on one species of sage, *Artemisia tridentata* Nutt. (Basin sagebrush), but when larval populations are dense they have been found occasionally feeding on various *Lupinus* and *Eriogonum*. Although *A. tridentata* is widespread in California, *hera* occurs only in the Great Basin habitat on the east side of the Sierra-Cascade ranges; from Inyo Co. north to Modoc Co., and is common in adjoining areas of Nevada and eastern Oregon.

Some populations of *hera* in northern California exhibit a great deal of variation. A series from Davis Creek, Modoc Co. contained typical specimens, melanic individuals, and the form *marcata* which has been treated as a subspecies (Figs. 1l–o). The form "marcata" (Fig. 1k) is one in which the black markings on the wings are greatly reduced; this form may be similar to "denudata" in *H. eglanterina* populations. The extent of variation observed in the Davis Creek area is almost identical to that found in nearby populations of *H. eglanterina shastaensis*. Further study is needed to determine the status of "marcata" and the extent of variation in the southern Oregon populations. *Hemileuca hera magnifica* (Rotger) is a subspecies from Colorado and New Mexico for which little biological data are available. Larvae from both states were collected and reared on *A. tridentata*. The larvae of *magnifica* were virtually identical in color and pattern to nominate *hera* larvae from Monitor Pass, Mono Co., California (Fig. 3e).

In California, overwintering eggs hatch in late April or May. Early instar larvae are black and gregarious; pupation occurs during July and August. Populations express a two year asynchronous life cycle with adults flying each year. When reared at lower elevations the moth expresses a one year life cycle, although some may hold over in the pupal stage for up to two years. McFarland (1974) published a partial description of a mature larva. A complete description of a mature 5th instar larva from Mono Pass, Mono Co., California is presented (Fig. 3e).

Description of Last Instar Larva

Head: Shiny black with numerous white secondary setae; diameter, 4.5–5.0 mm. Clypeus black with 4 long setae. **Body:** Length 55 to 62 mm; width, 9 mm. Ground color black. Ventral surface, light gray intersegmentally and gray-brown to black elsewhere. Sublateral scoli black. Lateral scoli with yellow rosette and branching black stalk. Dorsal scoli from thoracic segment 3 to abdominal segment 8 yellow rosette type. Body covered with numerous white secondary setae. Dorsal and lateral surfaces black. Body with 3 distinct lateral and 1 dorsal cream-white colored lines. Line I most conspicuous, passing through the sublateral scoli and extending length of larva. Line II, slightly ventral to lateral scoli and best developed in intersegmental area. Line III, midway between lateral and dorsal scoli, appearing as series of dashes. Line IV consists of series of dots or lines in intersegmental area and anterior portion of each segment paralleling black middorsal line. Thoracic shield, anal shield, and lateral shields of prolegs black. True legs black. Spiracles orange.

Hemileuca electra electra Wright

The dorsal forewing surface of *electra* (Figs. 2a, b) has a white medial area; the discal spot, costa, postmedial line, and margins are black. Although the forewing postmedial line is present in the females, its occurrence is variable in the males. The ventral surface of the forewing and both surfaces of the hindwings are red and black. The thorax is gray to black with white thoracic tufts and collar. The abdomen is red dorsally and black and white ventrally. *Hemileuca electra* can be distinguished from the Mojave Desert subspecies *clio*, by the well developed black postmedial line on the forewing of nominate females and the white area or series of white patches that occur between the postmedial line and the black wing margin. The latter characteristic is usually but not always diagnostic. In male *electra* the dark postmedial line or smudged area on the forewing touches the discal spot, whereas, in California *clio* populations it does not; male and female *clio* lack the dark postmedial line. The wingspan of male electra ranges from 45 to 54 mm; the females range from 53 to 62 mm.

Hemileuca electra flies from late August to early December with the majority of the records from mid-September to early October. Both sexes are active day flyers.

Nominate *electra* is restricted to the coastal chaparral plant community of five southern California counties and portions of northern Baja California, Mexico. Males have a fast erratic flight except when approaching a female. Adults fly from about 1000 to 1500 h and may be collected as they perch on various chaparral plants in the evening. Although wild females are infrequently captured, larvae and egg rings are frequently locally abundant.

The egg rings are deposited in the fall on the floral stems of *Eriogonum fasciculatum* Benth. Each egg ring contains 30 to 60 greenish ova which hatch in December or January. The host plant grows com-

monly in disturbed habitats such as road cuts and hill slides. In non-disturbed areas it is frequently associated with *Rhus laurina* and coastal sages. Mature larvae are found in late March or April. Comstock and Dammers (1939) described the mature larva and reported its length to be 45 mm, but most mature field collected larvae are larger. The larva is black with many secondary white setae extending from white pinacula giving it a gray-brown appearance. There are three continuous lateral cream-yellow colored lines extending the length of the body. The intersegmental area is red, and the setae of the dorsal rosette are yellow and black (Fig. 3h).

Hemileuca electra clio Barnes & McDunnough

Hemileuca electra clio (Figs. 2g–h) is similar in coloration to typical *electra*, but there are major differences in the pattern of the forewing. In *clio* from California the white medial patch of the forewing is well-defined and the postmedial line is undefined. Male and female *clio* are very similar in appearance. Specimens of *clio* from Arizona are usually larger, darker, and have a slightly different flight period than California populations. Some of the Arizona populations are almost completely black dorsally except for the basal area of the hindwing which is red. The wingspan of male *clio* from California ranges from 51 to 59 mm; females 51 to 69 mm.

California records indicate the flight period of *clio* is shorter than typical *electra*. Collecting records range from the first week of September to the first week of November with the peak flight period occurring in mid-September. Male *clio* are active day flyers, while females are usually captured in the afternoon and have been collected numerous times during the early evening at blacklights.

Hemileuca electra clio is found in the high desert regions of southern California and is frequently sympatric with *H. burnsi* and *H. neumoegeni*. The area occupied by *clio* has less precipitation, hotter summers and colder winters than the coastal chaparral community occupied by typical *electra*. Some populations of *clio* (in Riverside, San Bernardino, Imperial, and San Diego counties) on the eastern passes of the mountains which separate the chaparral from the desert plant community have hybrid like phenotypes suggesting that gene exchange has or does occur between the two taxa.

The author has crossed nominate *electra* from San Diego Co. with a wild male *electra clio* from Phelan, San Bernardino Co. The F_1 females were extremely variable, but definitely expressed the *clio* phenotype. The smallest female had a wingspan of 53 mm, was infertile, and had melanic forewings. The other females had melanic tendencies and wingspans that ranged from 63 to 68 mm. The males from this

cross were similar in appearance to, but on the average (54–58 mm) slightly larger than, normal *clio*.

The egg rings of *clio* contain 7 to 26 large gray eggs. The ova of *clio* are a different color, larger, and the rings contain far fewer eggs that those of typical *electra*. The larvae of *clio* feed on *Eriogonum fasciculatum* var. *polifolium* and are distinguished from typical *electra* by their larger size and coloration. Last instar larvae of *clio* from California and Arizona are similar in appearance; they have fewer white pinacula than *electra electra* and are darker in appearance. In addition the dorsal rosettes are solid black in *clio* but black and yellow in typical *electra*. Smith (1974) also noted these and other differences between the larvae.

Hemileuca juno Packard

The forewing of *juno* (Figs. 2c, d) is black with a white medial area. The hindwing of the male is black except for the center of the discal spot which is white. Females usually have lightly marked white medial area on the hindwings. Some specimens, especially females, have a gray-brown rather than black wing coloration. The thorax of the male is black while that of the female is frequently gray. The abdomen of the male is black anteriorly and red posteriorly; females are black with a red tip. The pattern of *juno* is similar to that of *electra clio* from Arizona. The wingspan of male *juno* from Arizona ranges from 52 to 59 mm; females 58 to 64 mm.

Although *juno* is widespread from Idaho to northern Mexico (Comstock and Dammers, 1939), it is infrequently collected except in Arizona and southern New Mexico. *Hemileuca juno* is assumed to occur in southern California, but the only record is from San Diego (Co.) and was collected in 1908. The larval host plant, *Prosopis juliflora* DC. (mesquite), grows commonly in the area of Anza-Borrego and many other locations in southern California. Despite a great deal of collecting activity in this area, there are no recent reports of larvae or adults from the California desert. The moth has been collected on the California–Arizona border at Yuma (XI-10-64).

In Arizona, first instar larvae are found in late April or early May. Although larvae will feed on the leaves of the host plant, they prefer the buds and flowers which develop in clusters. In captivity some larvae refuse to feed on anything but the flowers or buds. Pupation occurs in leaf litter near the surface of the ground during late June.

The mature larva measures about 50 mm in length and is black with numerous secondary setae extending from white pinacula which gives the larva an overall gray appearance. The head and true legs are black and the prolegs and ventral surface are gray-brown. The dorsal rosette

setae are uniquely colored with red at the base and black at the tips of the spines. There are 3 white and 1 black lines, all of which appear as a series of dashes on the lateral surface and extend the length of the larva. Comstock and Dammers (1939) described and illustrated the mature larva of *juno*, but their description was not complete (Fig. 3i).

Adults have been captured from late September to early December, with the majority of the records from later October to early November. Emergence occurs in the morning, and males begin to fly between 1000 and 1130 h. During a peak flight in 1982 females were observed ovipositing from late afternoon to at least sunset. The male flight dropped off considerably by 1530 h, and shortly thereafter, males were found perched on the host plant. By 1700 h most moths that were observed flying were females; although uncommon, females have been collected at blacklights.

Hemileuca burnsi Watson

The wings of *H. burnsi* (Figs. 2f, l) are chalk white and black. The antemedial black line is solid and is never intersected by an elongated spot as in *H. neumoegeni*. The black discal spot appears as a ring on the forewing but on the hindwing is often reduced to a simple black dot. The postmedial band is well developed on the forewing but frequently reduced or absent from the hindwing of males. Although the abdomen of the female is usually white, it may have semicircular bands of red and/or black; the abdomen of the male is white. The wingspan of male *burnsi* ranges from 48 to 52 mm; females 58 to 62 mm.

Collection dates indicate that the flight season extends from the last week of August to the first week of November, with the majority of the records from the second and third weeks of September. Records from Arizona, Nevada, and Utah also indicate September to be the month of the peak flight period in those states.

Male *burnsi* are active day flyers, generally flying between 0900 and 1500 h. They seek virgin females that remain perched on desert shrubs and transmit pheromone during the day. Females oviposit at night and are strongly attracted to light for the first few hours after it becomes dark and less frequently through the rest of the night. Upon emergence males are chalk white, but with age some become cream colored. Older specimens in collections are frequently light yellow.

The eggs overwinter and usually hatch in late February or early March. Early instar larvae are black and gregarious. Late instars are black with white pinacula, giving them a gray appearance. In addition the mature larva has at least two cream colored lateral lines extending the length of the body. Pupation occurs in April or early May. Com-

stock and Dammers (1937) described the first and last instar larva as well as the pupa of *burnsi* (Fig. 3g).

In the Reno area of Nevada the larval host plants are *Tetradymia glabrata* Gray and *Dalea fremontii* Torr. In southern California they utilize *Tetradymia axillaris* Nels. = *T. spinosa* H. & A., *Prunus fasciculata* (Gray), and various species of *Dalea*. Other plants associated with the *burnsi* habitat on the higher desert slopes near Little Rock and Phelan include: *Artemisia, Chrysothamnus, Ephedra, Eriogonum fasciculatum* var. *polifolium* (Benth.), *Larrea, Lycium, Purshia,* and *Yucca*. Although late instar larvae have been collected on *Eriogonum fasciculatum var. polifolium,* I have found that early instar larvae cannot survive on that host. After the 4th instar, successful development on *Eriogonum* did occur, and the resulting adults were of normal size.

Hemileuca burnsi is sympatric with *H. electra clio* in many areas of Kern, Los Angeles, Riverside and San Bernardino counties. I have seen one male specimen which may represent a hybrid between these two species. On occasion male *burnsi* have been attracted to a calling female of *H. electra*.

Hemileuca neumoegeni (Henry Edwards)

The wings of *H. neumoegeni* (Figs. 2e, k) are lustrous white. The distal spot of the fore- and hindwings is black and sickle-shaped with white centers; the antemedial and postmedial lines are also black. An elliptical black spot with a white center may occur in the antemedial forewing line. The thorax and head are red and the thoracic tufts are white. The abdomen of both sexes are similarly marked; red dorsally and laterally with a red and white ventral surface. Some females have white scaling on the dorsal posterior portion of the abdomen. *Hemileuca neumoegeni* is occasionally confused with *H. burnsi,* but the two are easily separated. The wings of *burnsi* are chalk-white and the antemedial line on the forewing is not interrupted by an elongated spot. The abdomen of *burnsi* adults is primarily or completely white rather than red as in *neumoegeni*. Male *neumoegeni* have a wingspan of 48 to 55 mm; the females from 58 to 64 mm.

The flight season extends from the second week of August to early October, with the majority of the records from the second and third week of September. Arizona, Nevada, and Utah records also indicate September as the month when most specimens have been captured. In California it appears that the occurrence of warm thunder storms early in the flight season enhances the September flight, while cold fronts have a retarding effect. Both males and females are nocturnal flyers

and are attracted to lights; most specimens have been collected prior to 2230 h.

The distribution of this species is more extensive than previously indicated (Ferguson, 1971); for in addition to Arizona, it has been collected in Utah, Nevada, and California. California records date back to the early 1930's. Adults and larvae have been collected in the Clark, Granite, Ivanpah, Mescal, Mid Hills, New York and Providence Mountain ranges of San Bernardino Co.

Adults emerge during the late morning but remain inactive during the day; mating occurs after twilight. There is some variation among the males with regard to the size and presence or absence of an orbicular-like spot in the antemedial line. Perhaps 20% of the California specimens lack or have a very reduced orbicular-like spot.

Females deposit 15 to 30 grayish ova in a ring near the terminal ends of the host plant and then move to another plant before depositing the next egg ring. In the Providence and New York Mts., egg rings and larvae have been collected numerous times on *Prunus fasciculata* (Torr.) and occasionally on *Rhus trilobata anisophylla* (Greene). Larvae in the Spring Mts. of Nevada were found on *P. fasciculata* by Eric Walter, while Mike Van Buskirk collected larvae south of Flagstaff, Arizona on *R. trilobata*. Both host plants are associated with dry slopes and washes in the Mojave and Colorado deserts above 1000 m. Bauer (1948) reported *Eriogonum fasciculatum* Benth. as the host plant and was cited by Ferguson (1971), but this record appears to be incorrect and may have resulted from misidentified larvae.

In California the ova hatch between early April and May. During the early instars the larvae are black and feed gregariously. In captivity young larvae on potted plants fed randomly throughout the day, but 4th and 5th instar larvae descended the secondary stems and remained on the main stems, frequently near the base of the plant during the day, and fed on the leaves of the terminal branches at night. Because mature *neumoegeni* larvae have a reddish brown intersegmental area and may be gray rather than black, they resemble *H. electra* larvae rather than those of *H. burnsi*, to which it is most closely related. Pupation occurs during June.

Hemileuca neumoegeni is sympatric with *Hemileuca electra clio* B. & McD. in the Providence and New York Mts., and populations of *H. burnsi* Watson occur in these same mountains. The larvae of *electra clio* feed on *Eriogonum*, primarily *fasciculatum*, while *burnsi* larvae feed on *Dalea*, *Tetradymia*, and *Prunus fasciculata*. Because of differential mating times, morning vs evening, there is little probability of interaction between *neumoegeni* and *burnsi* or *electra*. The larvae of *neumoegeni* are described here for the first time (Fig. 3f).

Description of Larval Instars

FIRST INSTAR. **Head:** Black, diameter 0.9 mm. **Body:** Length 6 mm, width 1.2 mm. Ground color, solid black. All scoli except dorsal thoracic and dorsal lateral simple with one long seta extending from each. Dorsal thoracic and dorsal lateral scoli forked at tip, with one slightly elongated seta extending from each branch. All scoli black.

SECOND INSTAR. **Head:** Black, diameter 1.4–1.5 mm. **Body:** Length 10–11 mm, width 2.4 mm. Ground color solid black. All scoli branched and black with black spines. True legs, prolegs, and spiracles black.

THIRD INSTAR. **Head:** Black, diameter 2.2–2.4 mm. **Body:** Length 17 mm, width 4.1 mm. Ground color solid black. Larva similar to second instar only larger.

FOURTH INSTAR. **Head:** Black, diameter 2.8–3.1 mm. **Body:** Length 24–36 mm. Ground color black. Ventral surface black with some white setae. Lateral surface with single undulating continuous white line extending length of larva and passing through base of lateral scoli. Faint traces of second white lateral line appears in segmental area only, in line with dorsal lateral scoli. Segmental area with numerous short secondary setae, some of which extend from cream to light pink pinacula. Intersegmental areas black. Mid dorsal area black. All scoli black and branched type. Prolegs black and covered with short white secondary setae. Planta orange. Spiracles black.

FIFTH INSTAR. **Head:** Black with numerous short white secondary setae, diameter 4–4.6 mm. Clypeus black. **Body:** Length 52–57 mm, width 10–11 mm. Ground color black to gray. Ventral surface gray with short gray secondary setae extending from white pinacula; intersegmental area red to flesh colored. Ventral and sublateral scoli with black shafts and white or black spines. Lateral scoli with black shafts with black and white spines and numerous white and black spines at base of shaft. Dorsal scoli on thoracic (T) segment 3 to abdominal (A) segment 8 of rosette type with gray centers and black tips. Three white or cream colored lateral lines divide lateral and dorsal surfaces into distinct color regions. Line I continuous and well developed undulating white-gray line extending length of larva, passing through base of sublateral scoli. Line II appears as series of gray dashes in intersegmental area only, below line of lateral scoli. Lateral surface between line I and II black with secondary setae extending from gray pinacula, giving area gray appearance. Intersegmental area with fewer pinacula and appearing black. Line III poorly developed and interrupted by reddish brown intersegmental area. Line III just ventral of dorsal scoli and extending length of larva. Segmental area between line II and III black; but secondary setae extending from gray pinacula giving area gray appearance; intersegmental area brick-red. Gray-black segmental and red intersegmental pattern continuing to black mid dorsal line. True legs black. Prolegs gray with light brown to red planta. Dorsal thoracic shield black. Proleg shield light brown to red-brown. Spiracles orange.

Hemileuca nevadensis Stretch

The wings of *H. nevadensis* (Figs. 2i, j) are black to dark gray with a wide cream colored medial band; both fore- and hindwings are similarly marked. The black discal spot on the forewing is lunate and larger than that of the hindwing. The abdomen is black; males have a distinctive red tuft at the tip, while females have a black or whitish tip. Some minor geographical variation is observed, as specimens from Nevada and northeastern California have slightly narrower black marginal borders than specimens from more southerly areas of California. The wingspan of California specimens ranges from 53 to 66 mm for the males; 58 to 67 mm for females.

The flight season extends from the third week of September to early December, with the majority of the records from the second week of

October through the first week of November. Both males and females are active day flyers.

Hemileuca nevadensis is widespread and locally abundant from extreme northern Baja California to the Los Angeles-Riverside basin and through the Central Valley to Turlock. In California this species is closely associated with the riparian habitat, where it feeds on *Salix*. The same host plant and habitat is occupied by *H. eglanterina* in the northern part of the Central Valley. This may have some influence on the distribution of *nevadensis*. There are scattered records for *nevadensis* along the Colorado River and the east side of the Sierras and Cascade ranges. Some populations on the east side of the Sierras may feed on *Populus* in addition to *Salix*.

The adults emerge in the morning and usually mate prior to noon. On cool cloudy days, moths have been seen in large numbers perched on plants along creek and river banks. Females may deposit over 200 ova in a ring on the woody thin stems of willow (Fig. 3k). The ova overwinter and hatch in late March or April. The immature stages have been described by Wright (1888), Dyar (1895), Packard (1914), and Comstock and Dammers (1939). Early instar larvae are black (Fig. 3l), but as the larva matures it develops yellow colored pinacula and assumes a black and yellow ground color. The prolegs have reddish brown patches near their base, and the prothoracic and anal shields are red. Larvae from northeastern California and Nevada have more yellow markings than those from southern or central California (Figs. 3j, l).

Genus *Coloradia* Blake

Adult *Coloradia* are characterized by their nocturnal habits, moderate to large size and their gray to black cryptic forewings. The hindwings are gray and either pink, cream, or light brown. Male antennae are quadripectinate, while those of the female are bipectinate or biserrate. Unlike *Hemileuca* the labial palps are large, separate, and not fused. Four species of *Coloradia* occur north of Mexico, two of which occur in California.

Members of the genus are widespread in pine forests of the western United States and portions of Mexico. The larvae feed on various species of pine. *Coloradia pandora* and its subspecies have caused economic damage to ponderosa, Jeffrey, and lodgepole pine forests in the western United States (Patterson, 1929; Wygant, 1941). Some species have a one year life cycle, while others usually require two years to develop from the egg to the adult. The larvae of *Coloradia* are similar to those of *Hemileuca* but have a dark gray to brown ground color and generally lack well developed cream or white lateral lines. In addition

some *Coloradia* lack the finely branched or rosette type scoli, and generally the spines are not urticating.

Coloradia pandora lindseyi Barnes & Benjamin

Male and female *C. pandora* (Fig. 2r) are similar in appearance but differ in size. Dorsally, the forewings vary from gray-brown to dark gray. The antemedial and postmedial lines are black and trimmed with white; the submarginal band is light gray. The hindwing marginal area is brown to dark gray, while the submarginal portion is white to pink. There is a brown or dark gray postmedial band and a distinct black discal spot. The remainder of the hindwing is cream, gray, or pink. The head, abdomen, and thorax are dark gray to brown with tufts of white scales. In California, *pandora* could be confused with *C. velda*, but the two are easily separated by size, flight season and appearance. The hindwing postmedial line of *velda* is diffused and frequently touches the discal spot, and the majority of the wing is gray; only 20 to 35% of the basal area is pink. In *pandora* the hindwing postmedial line is well defined and does not touch the discal spot; the majority of the hindwing is light brown, cream or pink. In California the wingspan of male *pandora* varies from 65 to 76 mm; females from 74 to 95 mm.

The flight season extends from mid-July to early October, with the majority of the records from early August to mid-September. Both sexes are nocturnal flyers and are attracted to lights. During massive population buildups, moths may fly during the day.

Coloradia pandora lindseyi inhabits Jeffrey pine forests and at times may be extremely abundant. Females deposit clusters of large white ova on the branches or needles of the pines (Fig. 4f). The eggs hatch in September or October, and the larvae begin to feed on the old needles. They pass the winter in the early instars high in the trees. Mature larvae descend the trees in June and July and pupate in the soil. The pupae may hatch that year or overwinter and hatch the following summer. Mature larvae measure over 58 mm in length, and have a brown to brown-black ground color (Figs. 4d, e). The posterior portion of each segment is dark brown, while the anterior and intersegmental area is light brown. There is a thin black mid dorsal line surrounded on each side by a thick dorsal white line. Two white lateral lines extend the length of the larva. The body is covered with light brown to cream colored pinacula from which extend short brownish secondary setae. The head is light brown. All scoli are short and the branches are much less developed than those of *Hemileuca* larvae (Fig. 4d). Although not described in detail, Patterson (1929) illustrated the immature stages of *lindseyi*.

Aldrich (1911, 1921) found that the Piute Indians near Mono Lake,

Mono Co. utilized the mature larvae as a food source, which they called pe-aggie. Once collected, the larvae were killed by heating, then dried and stored for future use. Engelhardt (1924) reported that indians in southern Oregon also utilized *lindseyi* larvae as a food source.

Mature larvae collected in the Laguna Mts. of San Diego Co. during early June pupated in loose soil. The pupation chamber was cup-shaped and consisted of soil and debris held together with a small amount of silk. Some adults emerged two months later in August, while others emerged in August of the following year. Similar results were observed by Aldrich (1921) with larvae collected at Mono Lake. Carolin (1971) found that *lindseyi* may remain in the pupal stage at least six years prior to emergence, but the majority emerged as adults during the first two years.

Populations of *pandora* undergo periodic outbreaks, during which time larval densities are sufficiently high to cause serious damage to commercial stands of pine. *Coloradia pandora lindseyi* damaged *Pinus ponderosa* Laws. in Oregon (Chamberlin, 1922; Patterson, 1929), but seems to prefer *Pinus jeffreyi* Grev. & Balf. in California. During the 1976 to 1982 outbreak near Mammoth Lakes, Mono Co., the larvae fed primarily on Jeffery pine but on occasion were found feeding on ponderosa and lodgepole pines (*P. contorta* Dougl.). Various papers have dealt with the biology and economic impact of *lindseyi* (Chamberlin, 1922; Engelhardt, 1924; Aldrich, 1921) but only Patterson (1929) provides much detailed information. Patterson did state that *lindseyi* is strictly a diurnal species, an observation which would distinguish this subspecies from other *Coloradia* (Ferguson, 1971). Contrary to Patterson's observations, I have collected *lindseyi* commonly at lights, and generally after 2100 h. Chamberlin (1922) apparently worked with Patterson during the 1919 Klamath Falls, Oregon outbreak and implies that the moths were attracted to lights. During the Mono Co. outbreak, the U.S. Forest Service estimates that 5000 acres of Jeffrey pine were defoliated in 1979 and about 16,000 acres in 1981 (Schaaf, 1980, 1981). Although the U.S. Forest Service only mentioned the nocturnal flights of the moth in their environmental assessment report, John Johnson informed me that some adults were observed flying during the day. It appears that the behavior of this species may change when populations are at high densities. During population explosions there is a potential for day flights, although most will probably still be active at night. At normal population levels all flight activity (mate seeking and oviposition) is at night.

Coloradia velda Johnson and Walter

The color and pattern of male and female *Coloradia velda* (Figs. 2p, q) are similar in appearance. The forewings are gray to gray-

brown; the antemedial and postmedial lines are dark gray to black and accented with white scales. The forewing discal spot is darker gray, smaller, and better defined than that of the hindwing. The hindwings are primarily gray to gray-brown with a slightly darker postmedial line that is adjoined to a distal pink line. The basal ½ to ⅓ of the wing is pink, as is the inner margin of the wing. In some specimens the hindwings appear partially transparent. The thorax and abdomen are dark gray with white scales mixed throughout. The only species similar to *velda* in California is *C. pandora lindseyi,* which is a larger species that flies later in the year. The hindwing of *pandora* is predominantly white or white and pink, and the discal spot is free of the gray postmedial line. In *velda* the gray from the margin extends all the way to the discal spot, and there are no extensive white areas. For additional comments see *C. pandora lindseyi.* Male *velda* have wingspans ranging from 51 to 61 mm; females from 58 to 73 mm.

Specimens have been captured from May to the end of July, but the majority of the records are for June. The adults are nocturnal and attracted to lights.

Presently *velda* is known only from the mountains of San Bernardino County. This species was recently described as a distinct species by Johnson and Walter (1980). Prior to its description it had been assumed to be a uniquely disjunct population of *C. doris* Barns.

Only the life history of *C. pandora* and its various subspecies have been described in the literature. Based on this information, the life cycle of *velda* is notably different from that of *pandora.* Larvae of *velda* emerge from the egg in early July and feed exclusively on pinyon pine, *Pinus monophylla* Torr. & Frem. Attempts to rear them from the 1st instar on *P. jeffreyi* were unsuccessful, but mature larvae may accept alternate hosts. The larvae feed gregariously in the early instars and singly in the 4th and 5th. They develop rapidly and after five instars pupate in mid-September. Larvae enter loose soil and burrow to a depth of 10 to 15 cm, then construct a structure around them by attaching silk to large soil particles and plant debris. The resulting pupae overwinter and adults emerge the following summer. By contrast, early instar *pandora* larvae overwinter, then feed to maturity in the spring, pupate during the summer and emerge later that same summer, or as is often the case, the following summer. Adult *velda* emerge between 0930 and 1100 h. Females begin emitting pheromones within one hour after it becomes dark; some females fly prior to mating. The developmental pattern of *velda* explains its early flight and suggests how it can occur sympatrically with *lindseyi* in the San Bernardino Mts. The main flight of *velda* occurs about two months prior to that of *lindseyi.*

Larvae of *lindseyi* and *velda* are easily separated. Mature *velda*

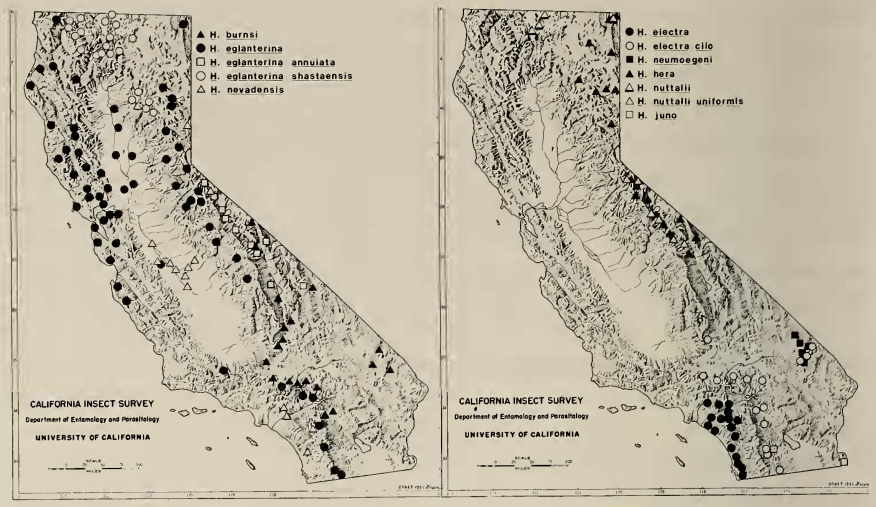

FIG. 5. The distribution of eight species and four subspecies of *Hemileuca* in California.

larvae (Figs. 4a, b) are light gray to gray-purple; the dorsal scoli are of the rosette type, orange in coloration, and similar in structure to those of *Hemileuca*. The larvae of *lindseyi* (Figs. 4d, e) have a dark brown ground color; the dorsal scoli are brown, and are a simple branched type. The larvae of *velda* are described here for the first time. The description is based on material reared from ova which were given to the author by Steve McElfresh. The ova were secured from a female collected at the type locality, Coxey Meadow, San Bernardino Mts., San Bernardino Co., on 25 June 1982 (Figs. 4a, b, c).

Description of Larval Instars

FIRST INSTAR. **Head:** Brown with sparse light brown secondary setae; diameter 1.5 mm. **Body:** Length 7.4 mm, width 2.1 mm. Ground color brown. Ventral surface yellow. Lateral surface with 3 lateral white bands. Line I encompasses the lateral scoli and extends length of larva. Line II, just ventral of dorsal lateral scoli and extends length of larva. Lateral surface between band 1 and 2 appears as dark brown band. Line III extends length of larva on dorsal side of dorsal lateral scoli. Abdominal dorsal and mid dorsal area yellow with remnants of black mid dorsal line. Dorsal thoracic segments dark brown to black. Lateral and sublateral scoli with short black spine. Dorsal lateral scoli with simple black spine twice length of lateral spine. Dorsal spines on abdominal scoli 1–8 black with brown setae at tip. Dorsal thoracic and 9th abdominal mid dorsal scoli branched with short brown setae extending from tips. Anal shield black, true legs dark brown, prolegs yellow.

SECOND INSTAR: **Head:** Brown with sparce light brown secondary setae; diameter 2.1 mm. **Body:** Length 10.2 mm, width 2.8 mm. Ground color brown. Ventral surface light brown. Lateral surface with 3 lateral white lines as in first instar. Brown line connects all dorsal scoli. Mid dorsal scoli yellow with thin brown mid dorsal line. Dorsal thoracic

FIG. 6. Habitat of desert, sagebrush and coastal chaparral species of *Hemileuca* in California. **a,** Coastal Chaparral, San Diego Co. Habitat of *H. electra electra, Saturnia walterorum* and *Hyalophora eurylaus*. Prominent vegetation in photo includes *Artemisia californica, Adenostoma fasciculatum, Eriogonum fasciculatum, Rhus laurina,* and *Salvia apiana*; **b,** Great Basin, Mono Co. Habitat of *H. eglanterina annulata, H. nuttalli uniformis, H. hera hera* and *Hyalophora gloveri*. Prominent vegetation in photo includes *Artemisia tridentata, Purshia tridentata* and *Symphoricarpos vaccinioides*; **c.** High Desert, San Bernardino Co. Habitat of *H. electra clio* and *H. burnsi*. Prominent vegetation in photo includes *Larrea divaricata, Yucca brevifolia, Tetradymia axillaris, Eriogonum fasciculatum* var. *polifolium,* and *Opuntia bigelovii*; **d,** High Desert Wash, San Bernardino Co. Habitat of *H. neumoegeni, H. electra clio,* and *Sphingicampa hubbardi*. Prominent vegetation in photo includes *Rhus trilobata anisophylla, Prunus fasciculata, Acacia greggii, Eriogonum fasciculatum* var. *poliofolium* and *Prosopis juliflora*.

area dark brown. Intersegmental areas white. Ventral, lateral and dorsal lateral scoli black. Dorsal scoli black on a yellow light brown pedestal. Dorsal, dorsal lateral, and mid dorsal scoli branched; thoracic scoli enlarged. True legs black. Anal shield dark brown. Prolegs light brown. Spiracles dark brown.

THIRD INSTAR. **Head:** Light brown with short white setae; diameter 2.4 to 2.7 mm. **Body:** Length 16 to 17 mm, width 4 mm. Ground color brown. Ventral surface light brown. Lateral surface with prominent white undulating line passing through base of each sublateral scolus and extending length of larva. Spiracular area light brown. 2nd white line extending length of larva, passing just ventral of lateral scoli. Brown line extending length of larva, passing through lateral scoli. 3rd white line extending length of larva, passing midway between dorsal and lateral scoli. Dorsal area white with thin black mid dorsal line. Thoracic and caudal scoli enlarged and branched. Dorsal and dorsal lateral scoli black and branched and on yellow pedestal. Sublateral and ventral scoli black and unbranched. Thoracic shield brown. Anal shield brown with white stripes. True legs black. Prolegs light brown. Spiracles brown.

FOURTH INSTAR. **Head:** Brown with light brown setae, ocellar scar dark brown; diameter 3.4–3.6 mm. **Body:** Length 28 to 32 mm, width 6 mm. Ground color gray. Ventral surface gray to yellow. Lateral surface with 3 light gray lines. Line I, undulating line extending length of larva and passing through base of each sublateral scolus. Line II, extending length of larva, passing just ventral of lateral scoli, and diffuse or absent. Line III, straight line passing midway between dorsal and dorsal lateral scoli. Mid dorsal area with thin dark brown mid dorsal line surrounded on each side by light gray line. Lateral and dorsal segmental area between light gray lines dark gray-brown with few light gray pinacula. A prominent gray dot occurs just dorsal of lateral scoli on abdominal segment 1 and occasionally on abdominal segment 7. All scoli branched. Dorsal and dorsal lateral scoli on yellow pedestal, base of spines yellow, distal portion black, except for black caudal scoli. Thoracic shield brown, anal shield brown with white stripes. True legs dark brown. Prolegs light brown to yellow. Spiracles light brown to yellow.

FIFTH INSTAR. **Head:** Light brown with few short white or hylen setae. Ocellar scar black. Clypeus brown. Mandibles dark brown. Diameter 4.5 to 5.5 mm. **Body:** Length 49 to 57 mm, width 10–12 mm. Ground color gray to gray brown. Ventral, lateral, and dorsal surface gray. Undulating subspiracular light gray fold extending length of larva. Lateral and dorsal surface with numerous folds on segmental and intersegmental area; brown line occurring at bottom of each fold. Dorsal and lateral surface sparsely covered with short hylen secondary setae. Diffuse light orange-brown area passing along base of dorsal scoli, extending length of larva, and surrounding light gray mid dorsal line. Shaft of all scoli orange. Sublateral, lateral and dorsal lateral scoli branched with white and dark brown spines. Dorsal scoli rosette type with white spines and black tips. Thoracic and anal shields light brown. True legs dark brown. Prolegs gray. Spiracles orange.

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LITERATURE CITED

AINSLIE, C. N. 1910. The New Mexico Range Caterpillar. U.S. Dept. Agric. Bureau Ent. Bull. 85(5):59–96.

ALDRICH, J. M. 1911. Larvae of saturniid moth used as food by California Indians. J. N.Y. Entomol. Soc. 20:28–31.

——— 1921. *Coloradia pandora* Blake, the moth of which the caterpillar is used as food by Mono Lake Indians. Ann. Entomol. Soc. Amer. 14:36–38.

CAROLIN, V. M. 1971. Extended diapause in *Coloradia pandora* Blake (Lepidoptera: Saturniidae). Pan-Pacific Entomol. 47:19–23.

CHAMBERLIN, W. J. 1922. A new lepidopterous enemy of yellow pine in Oregon. J. N.Y. Entomol. Soc. 30:69–71.

COLEMAN, J. 1983. A thousand *Hemileuca* in one night! Lepid. Soc. News (2):36–37.

COLLINS, M. M. & P. M. TUSKES. 1979. Reproductive isolation in sympatric species of dayflying moths (*Hemileuca*: Saturniidae). Evolution 33(2):728–733.

COMSTOCK, J. A. & C. M. DAMMERS. 1937. Notes on the early stages of three California moths. Bull. So. California Acad. Sci. 36:68–78.

——— 1939. Studies in the metamorphoses of six California moths. Bull. So. California Acad. Sci. 37:105–128.

FERGUSON, D. C. 1971. The moths of America north of Mexico. Fascicle 20.2a Bombycoidea (in part). Classey, London. Pp. 1–154.

——— 1972. The moths of America north of Mexico. Fascicle 20.2b Bombycoidea (in part). Classey, London. Pp. 155–275.

HUDDLESTON, E. W., E. M. DRESSEL & J. G. WATTS. 1976. Economic threshold for range caterpillar larvae on blue grama pasture in northeastern Lincoln County, New Mexico, in 1975. New Mexico State Agri. Exper. Station. Research Report 314.

JOHNSON, J. W. & E. WALTER. 1980. A new species of *Coloradia* in California (Saturniidae, Hemileucinae). J. Res. Lepid. 18(1):60–66.

MCFARLAND, N. 1974. Notes on three species of *Hemileuca* from eastern Oregon and California. J. Lepid. Soc. 28(2):136–141.

MICHENER, C. D. 1952. The Saturniidae (Lepidoptera) of the Western Hemisphere, morphology, phylogeny, and classification. Bull. Amer. Mus. Nat. Hist. 98(5):335–502.

PACKARD, A. S. 1914. Monograph of the bombycine moths of North America, part 3. Mem. Nat. Acad. Sci. 12. Pp. i–ix, 1–276, 503–516.

PATTERSON, J. E. 1929. The Pandora moth, a periodic pest of western pine forests. U.S.D.A. Tech. Bull. 137. 19 pp.

SCHAAF, R. 1980. Forest Service team to assess Pandora Moth effects. United States Forest Service, Inyo National Forest News, 11-4-80.

——— 1981. Pandora Moth outbreak in sharp decline. U.S. Forest Service, Inyo National Forest News, 4-29-81.

SMITH, M. J. 1974. Life history notes on some *Hemileuca* species (Saturniidae). J. Lepid. Soc. 28(2):142–145.

TUSKES, P. M. 1976. A key to the last instar larvae of west coast Saturniidae. J. Lepid. Soc. 30(4):272–276.

——— 1978. A new species of *Hemileuca* from the southwestern United States (Saturniidae). J. Lepid. Soc. 32(2):97–102.

WATTS, J. G. & T. D. EVERETT. 1976. Biology and behavior of the range caterpillar. New Mexico State Agri. Exper. Station Bull. 646.

WYGANT, N. D. 1941. An infestation of the Pandora Moth, *Coloradia pandora* Blake, in lodgepole pine in Colorado. J. Econ. Entomol. 34(5):697–702.